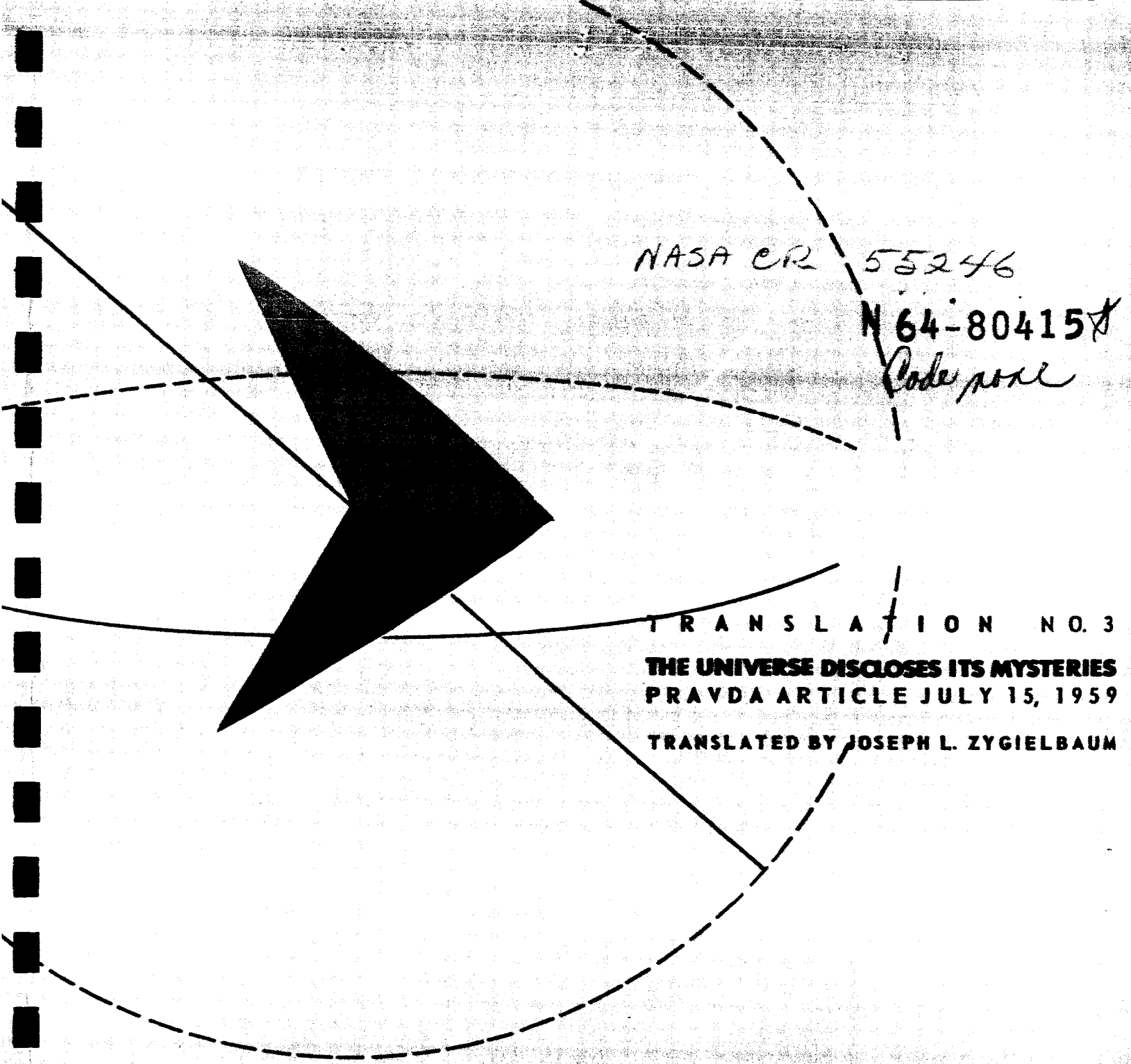

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THE UNIVERSE DISCLOSES ITS MYSTERIES

PRAVDA ARTICLE JULY 15, 1959

TRANSLATED BY JOSEPH L. ZYGIELBAUM

JET PROPULSION LABORATORY
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The Investigation of Cosmic Space With the Help of Rockets and Satellites

~~Pravda, July 15, 1959~~

~~Translated by Joseph L. Zygielbaum~~

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THE UNIVERSE DISCLOSES ITS MYSTERIES

The Investigation of Cosmic Space With The Help of Rockets and Satellites

Pravda, July 15, 1959

Translated by Joseph L. Zygielbaum

The historic date of October 4, 1957, when the first Soviet artificial earth satellite was launched, marks the beginning of the age of cosmic conquest. The weight of the first satellite was 83.6 kilograms.

Three months later, on November 3, 1957, the second Soviet artificial earth satellite was launched carrying a more complicated scientific instrumentation and an experimental animal, the dog Laika. The weight of this satellite was 508.3 kilograms.

On May 15, 1958 Sputnik III was placed in orbit. This satellite weighed 1,327 kilograms and represented an elongated, flying scientific laboratory.

The next significant success was achieved by Soviet scientists, designers, engineers, and workers on January 2, 1959, when the first cosmic rocket was launched. After passing by the moon at a very close distance, the rocket has departed from the vicinity of the earth forever, becoming a satellite of the sun, and thus, the first artificial planet. These successes are based on the achievements of the Soviet rocket technique.

We will repeat shortly the basic satellite parameters. The first satellite has existed for 92 days, the second for 162 days,

the third satellite will exist up to the fall of 1959. The initial rotation period of the first satellite around the earth was 96.2 minutes, the second satellite 103.7 minutes, and the third satellite 105.95 minutes. The altitude of the apogee (point of farthest distance from the earth) of the first satellite was 950 km, the second satellite 1,670 km, and the third satellite 1,880 km. The altitude of the perigee (point of closest distance from the earth) of the first satellite was 227 km, the second satellite 225 km, and the third satellite 226 km.

The orbits of all Soviet satellites had an inclination towards the equatorial plane of approximately the same angle, which equals 65°. As a result of air resistance, the orbit of the satellites during their flight gradually changes by its dimensions as well as by its shape. These orbits become less and less elongated and came closer to the surface of the earth. Since the length of the large orbital axis systematically decreased, then in accordance with the third law of Kepler the period of revolution of the satellite around the Earth became shorter continuously. The speed of change of the rotation period depends on the intensity of atmospheric drag of the satellite. A detailed analysis of the change of the rotation period depends on the intensity of atmospheric drag of the satellite. A detailed analysis of the change of the rotation period of the satellite has permitted us to determine some physical parameters of the atmosphere and has disclosed their daily and latitudinal variation.

The study of the readings of the instruments which were installed on the satellite have permitted us to investigate the character of satellite movement in relation to the mass center, which is necessary for an analysis of the measurement results.

The multi-stage cosmic rocket which was launched on January 2, 1959 has for the first time in history completed a flight to the region of the moon, passed the moon at a distance of 5000 km, and escaped the region of the earth's gravitational pull and become the first artificial planet of the solar system. The weight of the scientific instrumentation and power supplies aboard the cosmic rocket was 361.3 kilograms. The overall weight of the final stage of the cosmic rocket after fuel consumption was 1,472 kilograms.

It would be interesting to mention that the launching of the rocket in the direction of the moon from the territory of the Soviet Union is much more difficult than a launching from low latitudes. The territory of the Soviet Union cannot cross the orbital plane of the moon, which is located in this period approximately between the 18° northern latitude and 18° southern latitude, which eliminates the possibility to utilize for a flight through the region of the moon the very convenient trajectories which are located on the plane of the lunar orbit. These trajectories make it possible to develop an acceleration of the cosmic rocket in the most favorable conditions, when the direction of its flight in the acceleration sector is very little deviated from the local horizon. It is also important that during the rockets movement in the plane of the lunar orbit, less accuracy of the rockets navigational system is necessary for a flight near the moon, at a given distance.

We will also mention that not all days of the month are equally suitable for the launching of a cosmic rocket. For a launching from the territory of the Soviet Union the most favorable position of the moon in its orbit is when its inclination is at a minimum and consists of about 18° of southern latitude. Considerable variation from this condition will result in a essential decrease of the weight of the payload, and will consequently decrease the number of scientific instruments or even make the accomplishment of flight impossible. A day was chosen for the launching of the cosmic rocket such that when it passed the moon the position of the latter varied little from the optimum.

The successes which were achieved by the Soviet Union in the development of cosmic flight were possible thanks to the fact that the rockets which we have created possess a very high constructive quality. The newest achievements of Soviet science and techniques were utilized for the design and preparation of these rockets. The creation of perfect carrier rockets has required a great deal of scientific investigation and was based on the high level of our industry. We have created powerful, highly effective carrier rockets, which utilize high calorie fuel. Systems of automatic rocket navigation during flight were created which secured the stability of its position in space and its accurate travel along the assigned trajectory in the acceleration sector. In order to place an artificial earth satellite in orbit with assigned parameters or in order to accomplish a cosmic flight to a preassigned destination, extraordinarily high accuracy is necessary, and the velocity component

at the end of the acceleration sector should be held. A successful solution of these complicated problems during the launching of the Soviet satellites and the cosmic rocket represent a outstanding achievement of today's automation.

The launching of the Soviet artificial earth satellites and the cosmic rocket have made it possible to obtain results of fundamental scientific value in the investigation of the upper layers of the atmosphere and cosmic space.

We will bring below the results of these experiments by which the processing of scientific data was accomplished to a great extent. These results are taken from the material of the speech by the President of the Soviet Academy of Sciences, A. N. Nesmeyanov, at the general meeting of the Soviet Academy of Sciences, held in March of 1959.

The Investigation of Radiation Near the Earth and in Cosmic Space

Works in the field of cosmic ray study, which were conducted during the past years, have yielded many interesting results which are important for the solution of the problem of correlation of elementary problems in the presence of extra-high energies, as well as in the solution of the problem of the origin of cosmic rays. The theory which was developed by Soviet physicists and astrophysicists on the origin of cosmic rays during the explosions of extra-high stars has bound together such phenomena as cosmic radiation and cosmic rays, and gave a new approach to the solution of the problem on the origin of cosmic rays. In order to verify and further develop the theory on the origin of cosmic rays, in order to widen our assumptions on the properties of interastral and interplanetary space, new and more accurate information is necessary on initial cosmic rays, on fluxes of particles at such distances from the earth where the influence of the earth's atmosphere and the earth's magnetic field can be negligible. It is also necessary to obtain information on the change with time of the intensity of particle fluxes, on their "chemical" contents, and on the energetic spectrum of the particles which they contain.

This was the assignment undertaken by the physicists-investigators of cosmic rays when they conducted the experiment with the first artificial earth satellite. The results, however, proved to be unexpected; along side the original cosmic rays, at high altitudes was discovered a very intensive radiation, which consists of particles with comparably low energy.

The second Soviet earth satellite has for the first time conducted lengthy investigations of cosmic rays beyond the earth's atmosphere. On November 7, 1957 at 4:36 a.m. Moscow time, when the satellite passed over the region of 55° of geomagnetic latitude, a 50% increase of radiation intensity was registered. At this moment tracking stations on the earth's surface did not register any increase in the intensity. Consequently, this effect was caused by particles with small energies, which cannot reach the surface of the earth.

The third Soviet artificial earth satellite carried considerably more sensitive instrumentation, namely a luminescent counter. To the present time a large number of records have been processed. This data was taken during the satellite's flight at various altitudes and over various regions of the earth's sphere. It was proven that in all cases without any exceptions, when the satellite passed through the belt of geomagnetic latitude of 55-65° in the northern as well as in the southern hemispheres, a sharp increase of intensity in X-radiation was registered. The analysis of the obtained data has shown that the radiation which was registered by the instruments was created by electrons which have bombarded the body of the satellite. The energy of these electrons was on the order of 100 kev and less. During these experiments was discovered that the intensity of the observed radiation increases during the departure from the earth.

This fact shows that the particles come, not indirectly, from cosmic space and accomplish oscillations along the force lines of

the magnetic field. The magnetic field of the earth represents for the charged particles with low energies a unique "trap", in which the particles can move through practically closed trajectories over a very long period of time.

These conditions are not fulfilled on the magnetic force lines, which cross the earth on the geomagnetic latitudes, and which are greater than 65°, therefore the regions which are adjacent to the poles prove to be free from radiation. The area of space which is dominated by radiation, and which we discussed above, was named the external zone.

The most detailed data on the external zone was obtained during the flight of the cosmic rocket on January 2, 1959. In Figure 1 are presented the readings of one of the instruments (which measured ionization) in relation to the distance from the center of the earth. Distances are given along the horizontal axis in earth radii. Along the vertical axis is shown the radiation intensity in electron volts per second.

With the increasing distance from the earth the intensity of radiation increases in the beginning by hundreds of times, reaching a maximum at a distance of 4 earth radii from the earth's center, then it decreases sharply. Beyond the region of 10 earth radii a constant level, which corresponds to the cosmic radiation in interplanetary space, is reached.

The instruments of the cosmic rocket have permitted us not only to pinpoint the location of the external zone in space, but also to obtain new information on the contents of charged particles in this

zone. The effective energy of electrons in the region of maximum consists of about 25, and on the border zone about 50, kilo electron volts. After the rocket left the external zone at a distance of about 10 earth radii, these same instruments have measured, with high accuracy, the intensity of original cosmic rays, and also the hard electromagnetic radiations (X and gamma radiation) in interplanetary space.

In addition to the above described external zone of high intensity radiations, a second zone exists—the internal zone. Experiments conducted with American satellites have discovered a high intensity radiation in the region of the equator at an altitude of more than 1000 km.

With the help of the third Soviet satellite detailed data on this phenomenonwas obtained. It appeared that charged particles of the internal zone dominated the region from 35° of southern geomagnetic latitude to 35° of northern geomagnetic latitude, at an altitude of 1000 km. The altitude of the lower limits of the internal zone have proven to be different in the western and eastern hemispheres; in the east, 1,500 km, and in the west, 500 km. This circumstance is caused by the displacement of the magnetic dipole in relation to the center of the earth.

In contrast to the external zone, in the internal zone were discovered particles of high energies. An analysis of the data, obtained by Sputnik III, has proven that these particles are protons with energies of the order of one hundred millions electron volts.

Figure 2 represents a sketch of the most distant external zone which was discovered by Soviet physicists. Black represents the zone of high energy protons.

The third Soviet earth satellite and the cosmic rocket have also attempted to register particles of a very short run. Powerful fluxes of such particles were observed. These are electrons which produce an energy of about 10 kilo-electron volts. As a rule they travel along directions which are perpendicular to the magnetic force lines. Obviously the intensity of this radiation increases from the equator to the polar regions. It extends to distances which equal several earth radii.

A phenomenon was discovered which, as we assume, will put some light on a series of processes which take place in the upper atmosphere. There is no satisfactory explanation for the phenomena of aurora borealis as of today. The discovered powerful fluxes of particles might give the key to the understanding of this pheomenon. Actually, considerable energy in the form of high speed electrons is always present near the earth. A part of these electrons might periodically enter the lower layers and possibly this might be the cause for the aurora borealis.

High velocity electrons, colliding with atoms and molecules of the upper atmosphere, create X-rays, particularly in the zone of maximum distribution of the aurora borealis. The earth's atmosphere becomes the source of X-radiation. This radiation penetrating to altitudes of less than 100 km cause the ionization of more dense layers of the atmosphere.

Another part of X-radiation escapes into the outer space. Thus, the earth and possibly other planets might prove to be the sources of X-rays.

The question on the nature and origin of the aurora of particles around the earth is the center of attention of physics, geophysics, and astrophysics. Very little time has passed from the moment of discovery of this new phenomenon. Therefore, it is too early to make a choice from the various hypotheses which were proposed for its explanation.

On the symposium of the special IGY committee which took place in Moscow in summer of last year, the following hypothesis was proposed. Under the influence of cosmic rays the earth, as well as any other celestial body, becomes a source of neutrons. These neutrons appear as a result of cosmic rays exploding atomic nuclei, which are a part of the contents of the earth's atmosphere. The neutrons move away freely from the earth crossing its magnetic field. Near the earth, a part of the neutrons decomposes, forming electrically charged particles--electrons and protons. Disposing with comparably low energies, these particles become closed in, in the magnetic field of the earth. They cannot reach the earth's atmosphere or escape into interplanetary space. Consequently these particles will be astray for a long time in the magnetic field of the earth at distances on an order of thousands and tenths of thousands kilometers from the earth. The number of atoms that exist at such distances from the earth is very small. Therefore, a collision with atoms appears very seldom, and consequently the energy of these particles

will decrease very slowly. A lot of particles will accumulate over such a long period of time, and the intensity radiation will be very high. At the present time we may consider as established the fact that this process creates protons of high energy in the internal zone.

In order to fully explain the structure of the internal zone, it is necessary to establish which processes of particle escape from the zone cause its limitations in space.

On this account two hypotheses were presented, one of which presumes a sharp increase in the escape of protons with a high energy, at high altitude, due to the weakening of the magnetic field. The second hypothesis presumes the escape on account of quick oscillations of the magnetic field at geomagnetic latitudes of more than 35°.

In order to explain the origin of the external zone, the most perspective hypothesis is the one which the phenomenon is ascribed to the influence of fluxes of charged particles which come from the sun. During the period of brief solar activity, the sun discharges coagula of charged particles. These coagula also carry away parts of the magnetic field of the sun. The magnetic field of these coagula can be traps in which a considerable number of particles created on the sun accumulate. These particles might therefore inject themselves into the trap which is formed by the magnetic field of the earth. As a result particles which were carried over from the sun appear near the earth.

Finally we would like to mention that if the products of atomic explosions reach high altitudes, then they create there intensive fluxes of charged particles. Since the energy of these particles is low, they become trapped in the magnetic trap. Consequently the atomic explosions might lead to a "contamination" of cosmic regions adjacent to the earth.

In spite of the fact that from the moment of launching of the first artificial earth satellite, on October 4, 1957, only a little more than a year and a half has passed, the flights of satellites and cosmic rockets have brought with them outstanding discoveries. What was thought to be an empty space around the earth appears now to be an arena of phenomena which are extraordinarily essential in practical and scientific relations.

It is possible to make a prediction, which is of fundamental value for astrophysics, that such an aurora of particles will surround any heavenly body which possesses a magnetic field. The properties of cosmos change essentially near planets, whereby this takes place at distances many times larger than the dimensions of the atmosphere of these heavenly bodies.

According to data obtained from the cosmic rocket, cosmic rays in interplanetary space cannot have disastrously harmful effects on the organisms of future astronauts. It is true that this conclusion pertains only to a relatively peaceful cosmic space, which was present during the flight of the cosmic rockets.

In the region of maximum radiation near the earth its intensity is very great. Therefore, when a space ship will travel near the

earth or possibly near any other planet it should be considered that the body of that ship will be bombarded by high speed particles. This might lead to the appearance of ray illnesses in live beings.

Is there a protection against this radiation? Obtained data testifies to the fact that in the external zone protection is possible, but it would require a weight increase of the cosmic ship. In the internal zone, where the energy of particles is very high, the construction of an effective protection would require far-more-larger increase in weight. Therefore, the rocket trajectory along which the future astronaut will travel should be selected in such a manner that the period of travel of this space ship through the zones, especially the internal zone, will not be too lengthy.

The third artificial earth satellite carried aboard an instrument for the investigation of the problem on the presence of super heavy nuclei in cosmic rays. The Cherenkov detector has registered nuclei with a kinetic energy of more than three hundred millions electron volts per nucleon. The instrument was adjusted to register two groups of nuclei: with a charge of more than 15 and with a charge of more than 35. The data processing has shown that, on an average, through the instrument passed about one particle per minute, which possessed a charge larger than 15. Over a period of nine days only one case was noticed in which the channel, adjusted to register more heavy nuclei, was active. Thus it should be considered that the flux of heavy nuclei is very low. This fact is of essential value for further development of the theory on the origin of cosmic rays.

The Study of the Upper Atmosphere

One of the main problems which arises during the launching of satellites or rockets is the study of the structure of the upper atmosphere--a region which expends from an altitude of approximately 200 km to the external limits of the atmosphere. The investigation of the upper atmosphere is connected with the solution of a series of difficult problems.

One of these problems is the question of thermal balance of the upper atmosphere. At an altitude of 200 km the temperature of the surrounding environment equals 800 to 1000° and then increases to 2000 to 3000°. The high volume of temperature leads to a comparably slow drop of atmospheric density with altitude. What sources support such a heating of the upper atmosphere? Some indications to this question are given by new results obtained with the help of satellites and rockets, which we have mentioned above.

No lesser difficulties are encountered during an attempt to upset the balance of ionization in the upper atmosphere, that is, the process of establishing an equilibrium between the appearance of the free electrons and ions in the neutralization. The results of these experiments disagree with the theoretical calculations by a thousand to tenths of thousands of times, assuming that the process of neutralization takes place by ways of attaching the electrons to positive ions due to the energy of light quanta. It was clarified that the errors take place here much less in the presence of other particles which are similar to catalyzers and speed up the process sharply.

In order for these particles to regulate the neutralization process of electrons, it is sufficient that they represent only a one-tenth or one-hundred-thousandth portion of the number of neutral particles or free electrons. As such catalyzers can serve, for instance, the positive ions of nitrogen-oxide which were discovered at an altitude of more than 200 km with the help of a mass spectrometer which was installed on the third Soviet earth satellite.

In practice these investigations play a great role. It is well known that thanks to the electromagnetic properties of the ionosphere, radiation waves are propagated at great distances.

In connection with this, we can point out one interesting phenomenon which was known before but which appeared especially clear during the tracking of signals from the Soviet satellites. This phenomenon was called an antipodic effect and consists of the following: the force of the received signals increases at the point which is located in the antipod of the transmitting station. According to the records of the reception, results of radio signals from the first satellite in Antarctica at the station Mirnyi, it can be seen how radio signals from the satellite at a frequency of 20 megacycles were received when it passed over the vicinity of the settlement Mirnyi and in the antipod to it. Of great interest are such cases as when during a long period of time in the ionosphere, favorable conditions for "run off" of radio waves to a diametrically opposite point on the earth occur.

But the negative role of the ionosphere for practical purposes is also known. Its influence can, for instance, lead to errors when determining the coordinates, velocity, etc. during the utilization of

radio methods for the guidance of future interplanetary ships. In order to eliminate these errors it is important to know the structure of the ionosphere. In light of the above, the new values of scientific results obtained by Soviet scientists will be more understandable.

An important place in the investigation of the upper atmosphere takes up the determination of its density. Up to the moment of launching of the first Soviet earth satellites, sufficient reliable information was obtained only from altitudes up to 150 to 180 km. To altitudes of 250 km data on density obtained by various methods was extremely contradictory, and, in fact, the atmospheric density above 300 to 350 km was unknown.

Soviet scientists have studied the density of the atmosphere by various methods. By the decrease of the rotation period of satellites around the earth, due to drag, it is possible to determine, with sufficient accuracy at the orbital perigee, the volume which is proportional to the density of the atmosphere.

Sputnik III carried, for the first time, special type monometers with the help of which atmospheric density was measured in the region of the altitudes from 225 to 500 km.

In addition, the average course of density in the upper atmosphere at an altitude from 320 to 1000 km was calculated on the basis of results of determining the electron concentration by radio signals from the first and second satellites. An original method was also utilized, based on observation of dispersion of the sodium cloud which was formed at an altitude of 430 km during the launching of a high altitude rocket. By the character of dispersion of this cloud the

density of the atmosphere at the given altitude was calculated, based on the theory of diffusion. A similar cloud was further utilized for the creation of an artificial comet by the Soviet cosmic rocket.

The results of determining the density are shown in Figure 3. On this graph density is converted, according to recent data, to a number of new neutral particles per cubic centimeter.

These investigations which coincide with each other have permitted us for the first time to make a reliable determination of the atmospheric density up to altitudes of 600 to 800 km. These investigations have proven the error of a series of assumptions which existed during the period before the launching of the satellite, on the basis of which images of the atmosphere were constructed. A regular observation of satellite drag has disclosed the latitudinal and daily changes of density. From the satellite drag was also obtained some data on temperature of the upper atmosphere. At altitudes of 228 and 368 km, the temperature changes within the limits of 800 to 1500°, respectively.

With the help of the mass spectrometer, which was installed on the third satellite, a great number of mass spectra of positive ions was obtained, which characterized the chemical contents of the ionosphere at an altitude of from 226 to 1000 km. Changes occured in intervals of mass numbers from 6 to 48 atomic units. As a result of mass spectrometer measurements its was established that ions with a mass number of 16 are prevailing in this area, and consequently from an altitude of 425 km to an altitude of at least 800 km the basic gas component, thanks to which the ionosphere exists, is atomic oxygen.

In addition to ions of atomic oxygen, ions of atomic nitrogen were also registered. Heavy particles with a molecular weight of 28 and 30 atomic units were also discovered. Ions with a mass of number 30 may be identified with ions of nitrogen oxide, and in light of the above, their discovery at altitudes up to 350 km is an occurance of great interest and might help to solve, by further improvement of this data, the questions as to the balance of ionization of the upper atmosphere.

The relative content of atomic nitrogen in relation to atomic oxygen varies from 1 to 10% depending on the altitudes and geographical latitudes, and it also changes with time. The relative content of heavy ions of nitrogen oxide and molecular nitrogen sharply drops with the increase of altitude. The number of ions of nitrogen oxide at an altitude 230 km is from 25 to 40% in relation to the atomic oxygen.

A large amount of material has been obtained which discloses the determined dependence of all discovered components of the ionosphere on the geographical latitude. Particularly at alitudes from 226 to 260 km, a sharp increase in the content of ions of atomic nitrogen are observed in the region of approximately 60° of the northern latitude.

Data which was obtained by the help of a mass spectrometer has made it possible to establish the fact that the satellite had a negative potential on a mean order of 5 volts during daytime.

Important results were obtained on the determination of the concentration of the charged particles. Various radio methods have permitted us to study, with the help of equipment located on the earth,

the distribution of electron concentration only to an altitude of the main maximum of the ionosphere, which varies in different conditions within the limits of about 300 to 400 km. On the other hand the question on the course of electron concentration above the maximum remained open up to the launching of the first satellite, in spite of the fact that some investigators have considered that above the main maximum the electron concentration quickly drops, particularly on the basis of the data obtained with the help of American rockets.

This problem was investigated by various methods in the Soviet Union. An analysis of the trajectory of radio signals from the first earth satellite has made it possible to determine the mean cause of electron concentration of the internal ionosphere, above the main maximum, at altitudes from 320 to 650 km.

During a vertical launching of a Soviet geophysical rocket on February 21, 1958, the distribution of electron concentrations to altitudes up to 470 km was directly measured for the first time.

Sputnik III has for the first time conducted measurements, with direct methods, of the concentration of positive ions along the orbit of the satellite to an altitude of 900 to 1000 km. These measurements were conducted with the help of so-called ion traps. These ion traps have made it possible to obtain extensive experimental data. Since the concentration of positive ions in the upper atmosphere is approximate to the concentration of electrons, then in the same time these experiments gave information on the electron concentration. Experiments utilizing traps have also permitted the measurement of the negative electric potential of the satellite in relation to the

surrounding environment. On orbital sectors which were illuminated by the sun, this potential proved to be equal to from 1 to 7 volts.

The volume of the negative potential of the satellite can obviously be interpreted as a result of the influence of high speed electrons, the energy of which surpasses considerably the average energy of the atmospheric particles. The results of the investigation on the concentration of charged particles above the main maximum of the ionosphere are shown in Figures 4 and 5. The drop in the electron concentration above the main maximum takes place slower than the increase in the lower parts of the ionosphere.

The extrapolation of these data in the direction of higher altitude lead to the assumption that at an altitude of 2000 to 3000 km the electron concentration should reach values of not less than several hundreds of electrons per cc; that is, it would equal the assumed value of its density in interplanetary gas. The earth's atmosphere obviously extends at least up to 2000 to 3000 km, and the previous assumption that its limits are approximately at an altitude of 1000 km should be rejected.

Investigation of Interplanetary Gas

The Soviet cosmic rocket has conducted the first experiment on the direct study of gas components of interplanetary matter.

The instrumentation which was installed on the cosmic rocket was designed to conduct the first stage of investigations, namely an attempt for a direct experimental discovery of the ionized interplanetary gas in the region between the earth and the moon. This instrumentation consisted of four, pre-electrode traps for positively charged particles (protons), the perforated covers of which were charged to various potentials in relation to the body of the container. Such instruments did not give any possibility to consider to the full extent the influence of the electric potential of the container in relation to the surrounding environment on the conducted measurements. Therefore, it was impossible, with these instruments, to conduct accurate measurements of the concentration of positive particles (such measurements will be made in the future). It was only possible to obtain primary evaluations, based on the values of registered fluxes. These fluxes, which were created by positive particles in the collector circuits of the traps, characterized the concentration of particles of ionized gas on the rockets course.

The results of this experiment are being processed at the present time. Nevertheless it is already possible to present some data which are of considerable interest.

According to preliminary data the concentration of positive charged particles at an altitude of 1500 km in the unilluminated region of the atmosphere is of the order of 1000 particles per cc. By increasing the altitude to 2000 km (in the nonilluminated region) the

concentration of positive particles drops approximately by 1.5 times. At a distance of 21 to 22 thousand km from the surface of the earth the concentration of positive particles proved to be approximately equal to the concentration in the shaded region at an altitude of 2000 km. At a distance of 110 to 150 thousand km, fluxes were registered in the traps, which allow us to consider that in this sector of the rockets course the concentration of positive particles is of the order of 300 to 400 particles per cc.

Setting up this experiment has for the first time permitted us to evaluate the concentration of ionized gas in interplanetary space, not on the basis of doubtful observations from the earth, which create disagreeable interpretations, but by way of direct measurements.

The Study of the Earth's Magnetic Field

The knowledge of the earth's magnetic field at high altitude above the earth's surface is of great value for a series of problems on the earth's magnetism. As a result of an analysis of magnetograms, which were obtained with the help of a magnetometer installed on Sputnik III, it was possible to make a series of conclusions of a fundamental geophysical value.

In correspondence with recent ideas on the character of the daily variations of the earth's magnetic field, it might be anticipated that effects of magnetic disturbances can be best investigated in that case when the satellite passed twice through one and the same course of the earth's sphere: One time during a peaceful condition of the field and the second time during a disturbed condition, and if possible during different hours of the day. The measured values of the field, in these cases, should differ in volume, which is equal to the effect of the external flux system or a part of it. Furthermore, these variations should have opposite signs for the corresponding sectors of the trajectory at the morning and evening parts of the earth, since the positive and negative vortices of the magnetic disturbances exist simultaneously and the satellite passed through them during a period of 12 to 15 minutes.

The magnetic investigations conducted by Sputnik III have convincingly proven the presence of ionospheric sources which cause variations in connection with the disturbances of the earth's magnetic field. During an analysis of magnetograms, which were obtained from the satellite, 20 cases of short-lasting (five to eight seconds) negative and positive peaks of magnetic field changes were discovered.

They can be ascribed to the nonuniformity of space in the ionospheric flux systems of a local character, through which the satellite crossed.

These results are of great value for the construction of physical ionospheric models, and also for the quantitative theory on magnetic disturbances.

New valuable data was obtained during the investigation of the constant magnetic field of the earth. The most interesting data was obtained during the flight of the satellite above the region of the East-Siberian world magnetic anomaly, the so-called "Asiatic maximum of intensity of the geomagnetic field." The analysis of the magnetograms and their comparison with the course of the superficial cause of intensity of the magnetic field along the track of the satellite flight indicate the slow decrease of the anomaly. This fact is of great importance for the solution of the problem on the depth of the layer of sources of world anomalies and on the nature and structure of the magnetic field of the earth. A conclusion can be drawn from this fact on the depth of origin of sources of the East Siberian magnetic anomaly.

Of extremely important value are the results obtained during the measurements of the magnetic fields of the earth with the help of the cosmic rocket. At a distance of approximately two earth radii from the center of the earth, the size of disagreement between the measured values and the values which were calculated theoretically (Figure 6) become noticeable and continue to increase.

The original field decreases more rapidly and at a distance of approximately 20,800 km from the earth's center it has a minimum which equals approximately 400 gamma, that is of the order of one hundredth

part of field intensity on the surface. Then, an increase of field intensity was observed to a maximum value of 800 gammas at a distance of 22,000 km, and its decrease which follows. Such a change in the magnetic field of the earth might be explained only by an assumption that the rocket passed through a current layer at altitudes of 20 to 21,000 km. Thus, the measurements on the cosmic rocket have indicated the reality of the existence of a flux system outside of the ionosphere.

This fact is of fundamental value for the theory of magnetic storms and the aurora borealis and particularly for the critical evaluation of present-day explanations for mass phenomena.

Another circumstance of considerable importance is the fact that the effect of a current layer was disclosed during a very peaceful day as far as magnetism is concerned, and the closest magnetic disturbance (magnetic storm) took place almost a month before this. The system of fluxes outside of the ionosphere, which arises during the period of the most intensive magnetic storms, may obviously, exist over a long period of time.

The obtained experimental material is undoubtedly the subject of theoretical investigations in the field of geomagnetism as well as in the adjacent departments of geophysics and physics of plasma. Of great interest is the explanation of the relation between the measured maximum of the magnetic field and the aurora of charged particles.

The magnetometer which was installed on Sputnik III has made it possible to obtain data on the orientation of the satellite in space and to study its movement in relation to the center of gravity in

addition to the measurements of the magnetic field of the earth. These data are necessary during the deciphering of the results of the majority of experiments which were simultaneously conducted by the satellite.

Micrometeors

For the registration of meteoric particles the third Soviet artificial earth satellite carried an instrumentation which made it possible to register the number of impacts of particles and their energy. This energy was determined by the impulse volume of the material of the detector, which was discharged during the explosion of the meteoric particle on its surface.

If one should proceed from the theoretical dependence between the energy of the meteoric particle and the impulse, and assume that the mean velocity of the particle equals 40 km/sec, then during the period of operation of the instrumentation, impacts of particles were registered with a mass from one-eight-billionth to two-hundred-millionth part of a gram, which possess an energy on the order from 10,000 to 100,000 erg.

As was reported at the fifth reunion of the IGY, an increased number of impacts, in comparison with the preceeding days, was registered on May 15, 1958. During this day four to eleven impacts per second took place in 1 sq meter. On May 16 and 17, the number of impacts decreased by 4000 times, then by 50,000 times, and finally it became less than 600,000 times on May 15.

The numerical value of the coefficient of proportion between the impulses which were registered by the detector and the energy of the particles will finally be determined experimentally (by ways of miniature scale operation).

A conclusion can be drawn from the experiment, made by the cosmic rocket, that particles with a mass of about 1 billionth part of a gram

might encounter the surface of the rocket one time in a period of several hours.

As is obvious from the results of the measurements by Sputnik III and by the cosmic rocket, the meteoric and micro-meteoric danger is small.

Biological Investigations

The creation of a new branch of science--cosmic biology--took place in the present time. One of its most important purposes is to secure the safety of a human flight through the universal space.

Investigations, which were conducted on rockets, have shown that experimental animals have satisfactorily withstood the effects on their organism of various, in character and nature, factors during their flight.

The materials, which are accumulated at the present time, allow us to draw the conclusion that, in conditions which are proximate to cosmic flight, the basic physiological functions of experimental animals do not undergo any noticeable changes. The most complex problem proved to be the assurance of the safe descent of the animals to the earth.

At the present time we have succeeded in achieving a known success in this direction. Experimental animals were satisfactorily returned to earth from altitudes of several hundred kilometers. Great possibilities are presented by the artificial earth satellites in which the conditions from a biological standpoint are the closest to the conditions of cosmic flight.

A detailed analysis of scientific information from the second earth satellite has permitted us to obtain a series of interesting new data. These pertain first of all to a continuous effect of weightlessness.

Of great importance proved to be the circumstance that during weightlessness no unfavorable reactions on the part of vegetative

functions of the animals were recorded. That is, the animal did not show any considerable restlessness due to movement.

In Figure 7 is shown the dynamic of change in the heart activity of the dog Laika at various moments of the satellites flight. The curve in the graph indicates the variations in the frequency of the heart systole. It is not difficult to notice that acceleration, vibration, and noise during the placing of the satellite in orbit has caused a sharp increase in frequency of the heart beat, reaching a climax. Under conditions of weightlessness the frequency of pulse gradually returned to its original level.

The character of the peaks in the electrocardiogram (Figure 8), the breathing movements, and the motion activity did not show any noticeable deviations from normal.

The intervals in the electrocardiogram vary in general, corresponding to the changes in frequency of heart systoles. This testifies to the fact that the operational functions of the heart muscles were not affected.

As a whole, the evaluation of the obtained results has clearly shown that the conditions, which are approximate to cosmic flight, are withstood fully satisfactorily by a highly organized animal.

Basic Trends in the Development of Cosmic Flights

Soviet scientists, designers, engineers, and workers have played an outstanding role in the launching of artificial earth satellites and the cosmic rocket, with the help of which the direct study of cosmic space was realized. A lot of praise belongs to our mathematicians, mechanics, and physicists of various specialties. Actually there isn't a single field of natural sciences which did not participate in one way or another in the solution of the problems in the investigation of cosmic space. This synthesis of science and technique has yielded noticeable results, which already permit us to predict the road which will be taken in the further development of cosmic flights.

In the near future the development of cosmic flights will go in various directions. One of these directions is the flight of satellites in the vicinity of the earth; a second direction is the solution of problems related to flights towards the moon and the mastering of the moon. A third direction is the investigation of the near-solar space, the planets of the solar system and flights towards other planets.

Artificial earth satellites have permitted us to solve a great number of scientific and applied problems. Already the first Soviet satellites have made it possible to conduct a great number of investigations, to study a series of phenomena in the upper layers of the earth's atmosphere and in the adjacent regions of cosmic space.

Further developments of work on the construction of satellites will go in the direction of widening the circle of scientific investigations as well as in the direction of solving with the help of satellites pure applied problems.

It is expedient to create artificial satellites, which will be oriented in a determined manner in space. Orientation is necessary for the solution of many scientific problems. It is wishful thinking that the satellite be oriented towards the sun for a series of investigations in relation with the sun. For investigations connected with the earth and atmosphere the most appropriate appeared to be an orientation when one of the satellites axes is directed towards the sun and the other coincides with the direction of its movement in orbit. For astrophysical investigations it seems to make sense to have a satellite which will conserve an unchangeable position. relative to fixed stars.

The most important stage in these investigations appeared to be the flight of a human being in a satellite, which requires the solution of a great number of complex problems connected with assuring security and the creation of the necessary conditions for human activities during the period of ascent and descent under the influence of great accelerations, as well as during the period of orbital flight in a state of weightlessness. An experiment with animals, which was conducted on the second Soviet artificial earth satellite, was the first notable step in this direction, which yielded scientific material on the effects of cosmic flight conditions on a live organism.

Many times we have toyed with the idea of the possibility of using a system of special satellites for the retranslation of television transmissions which would possibly secure long distance transmissions along waves of an ultra-shortwave range without the use of radio relay lines or a net of cables.

It will be possible to organize, with the help of satellites, a constant service for the observation of corpuscular solar radiation, which might secure a prognosis on important phenomena which take place in the upper layers of the atmosphere.

It is difficult to predict at this time all the possibilities of satellite utilization for scientific and practical purposes, just as in the beginning of aviation it was impossible to predict all phases of application in the extensive progress of present day aviation.

The second direction in the development of cosmic flight is a series of questions connected with the conquest of the moon. The flight of the Soviet cosmic rockets has marked the beginning of an era of lunar flights and flights to the near solar regions of space.

We might imagine, even if not in the very near future, a manned flight to the moon with landing and a return flight to the earth. The problem of landing instrumentation on the surface of the moon is quite complicated. No less difficult is the problem of starting a rocket for the return trip from the moon to the earth.

In the more distant future during the process of moon conquest it might be considered to set up special stations on the moon similar to those scientific stations which are organized in the hard-to-reach

regions of the earth, as for instance the polar regions. In addition, it is not necessary to indicate the extraordinary complexity of such a undertaking. Its realization will become possible only as a result of an essential progress of rocket technique and the solution of a large number of scientific and technical problems. But it might be that the projects which seems to be fantastic and unaccomplishable today will become realized considerably sooner than we might imagine at first glance.

The third group of problems which represent a separate direction in the development of cosmic flight are the problems connected with the investigation of the near solar space and planets of the solar system.

One of the purposes of flight through the realms of the solar system is the direct study of interplanetary environment. Probing of interplanetary space with the help of scientific instrumentation permits us to establish the density of interplanetary gas at various distances from the sun, to determine the chemical contents of interplanetary gas. This will give new, extremely interesting data on the distribution of intensity and the contents of cosmic radiation at various regions of the solar system. It will permit us to investigate various forms of solar radiation, the magnetic fields of the sun, and its influence on the phenomena in interplanetary environment.

Of special interest is the investigation of planets of the solar system, in the first place Venus and Mars. As was shown by an analysis, a flight towards the planets of the solar system is

expedient in order to accomplish during predetermined time intervals when the reciprocal position of the earth and the planets will permit to accomplish a flight with a minimum loss of energy during the rocket's acceleration.

The launching of rockets equipped with automatic instruments to the planets will permit us to investigate their magnetic field, their radiation belts, and to receive a detailed description of their surface. It will be possible to investigate the atmosphere of the planets, to determine their density, chemical contents, degree of ionization, and also to investigate the structure of the surface of the planets and their temperature. Finally, very alluring is the prospect of investigating forms of life on other planets. The flight of a man to another planet will be a task of the future; however, the day for this achievement will come.

The development of cosmic flights puts before science and engineering a great number of complex problems of a scientific and investigating, as well as engineering and designing, character.

In order to determine the parameters of a trajectory, the transmission to earth of measurement results, and information on the operation of the instrumentation, and also for the transmission of commands from the earth, the most important problem is a long distance radio communication. The launching of the first Soviet cosmic rocket established for the first time in history a radio contact at a distance of about five hundred thousand km from the earth.

During flights through realms of the solar system it will be necessary to establish a radio contact and transmission of radio

images at a distance of the order of tenths and hundreds of millions of kilometers. Of special importance, in view of this fact, is the problem of creating a light, small-dimensional and very economical radio apparatus, and also powerful transmitting and sufficiently sensitive receiving stations on earth.

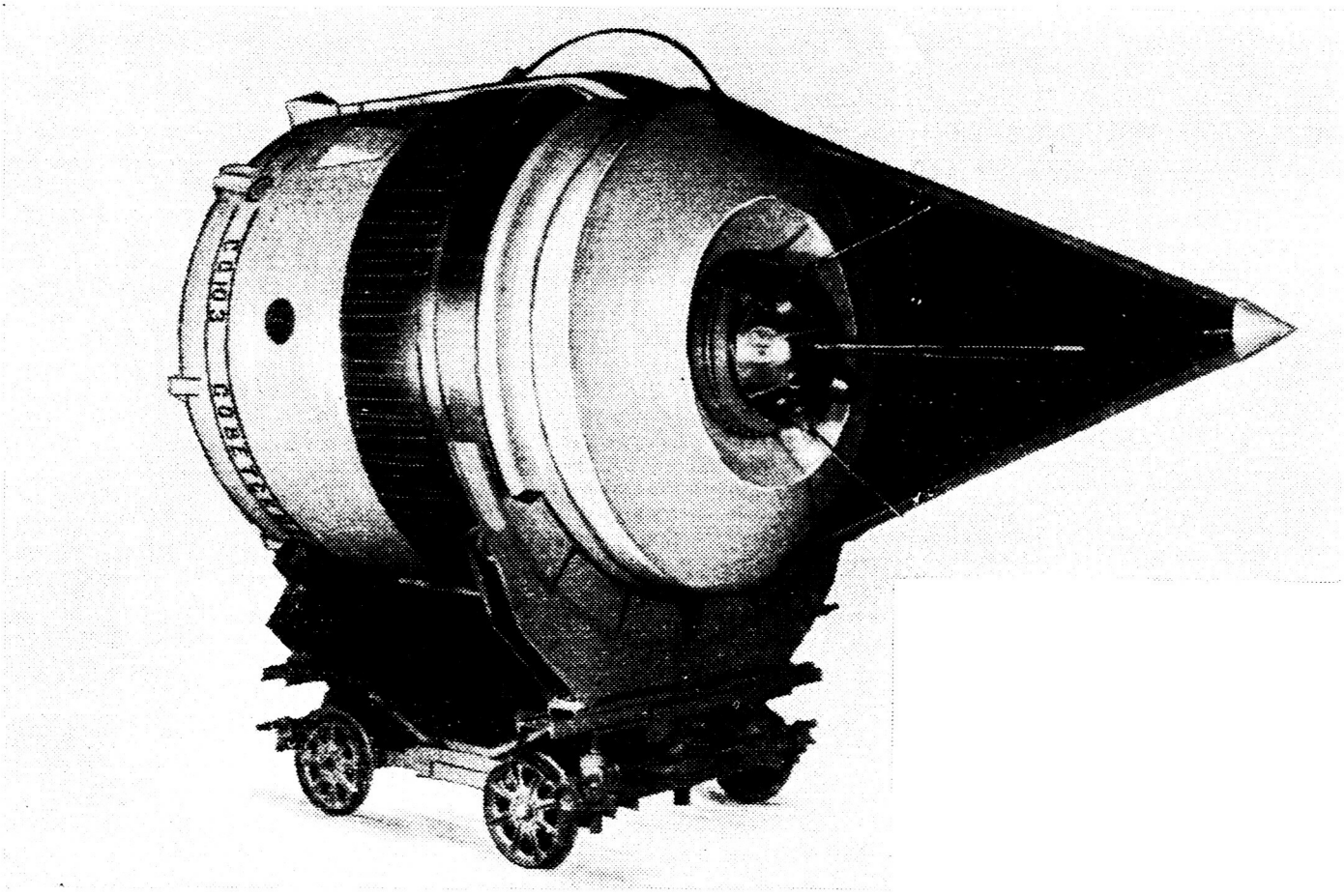
The entire instrumentation of cosmic rockets should be not only extremely light weight and economical but also extraordinarily reliable, capable of faultless operation over a period of many months and maybe of several years. The endurance of such a regime is characteristic for flights through the realms of the solar system, and there is nothing astounding in it if we will remember the period length of the rotation of planets. The specific character of the operation of the instrumentation in cosmos is determined also by the effect of cosmic radiation and the presence of a deep vacuum which surrounds the cosmic ship. An important circumstance is the necessity to conserve a determined thermal regime which is necessary for the normal operation of the instrumentation. One of the more serious problems of cosmic flight is the protection against meteorites.

The series of problems connected with the calculation of the movement of cosmic ships are presented by the new direction in celestial mechanics. For the first time in the history of astronomy, calculations are conducted on the movement of artificial celestial bodies, which includes also such unusual celestial bodies which might in itself actively effect the character of its movement. The study of the movement of these artificial bodies permits us to obtain new data on the astronomical constants of the solar system in gravitational fields.

We are witnessing the birth of a new chapter in astronomy, which might be called experimental celestial mechanics.

The progress of development of cosmic flights--of this entirely new field of human activity--presents very high requirements of science and technique; mentioning only the very new and prime requirements--the creation of new scientific and technical directions.

There is no doubt that the Soviet scientists, designers, engineers, and workers, who are inspired by the great program of building a Communist society in our country, which was emphasized at the XXI Congress of the Soviet Communist Party, have honorably accomplished the solving of these interesting contemporary problems, and we are all witnessing the new glorious achievements of the Soviet Union in the conquest of cosmic space.



Макет последней ступени космической ракеты на монтажной тележке. Половина носового конуса снята, виден отделяемый шарсвой контейнер с аппаратурой.

Mock-up of final stage of the cosmic rocket on the assembly cart. One half of the nose cone is removed, displaying the detachable spherical instrument container.

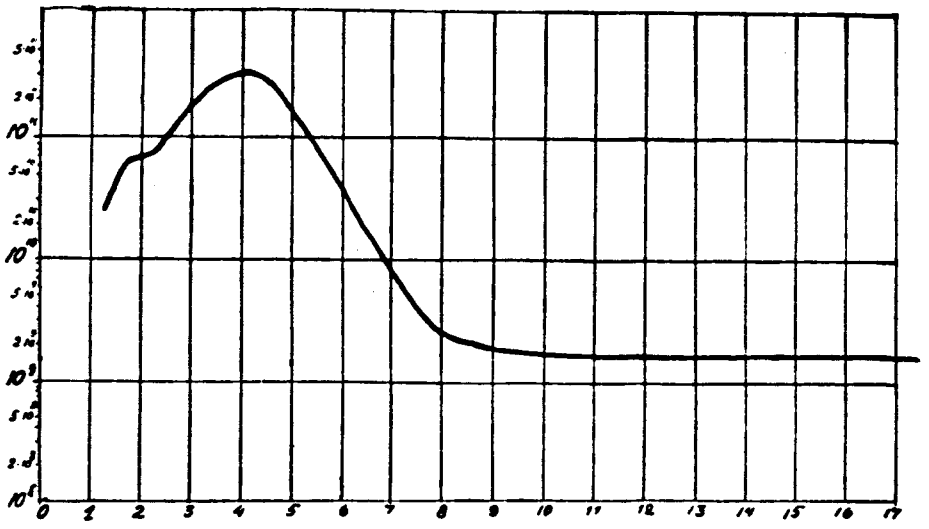


Рисунок 1.
Кривая изменения интенсивности радиации в зависимости от расстояния от Земли.

Figure 1. Curve of radiation intensity change in relation to the distance from the earth.

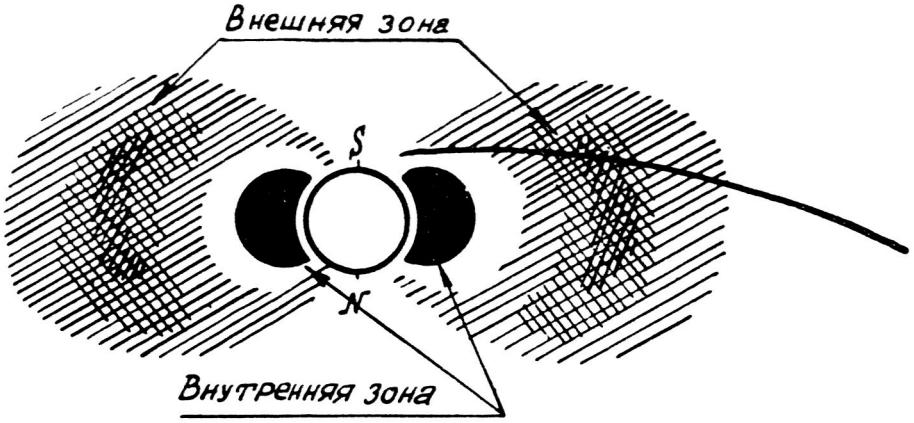


Рисунок 2.
Конфигурация окружающих Землю зон повышенной радиации.
Сплошная линия — траектория движения космической ракеты.

Figure 2. Configuration of increased radiation zones which surround the earth. The continuous line is the travel trajectory of the cosmic rocket.

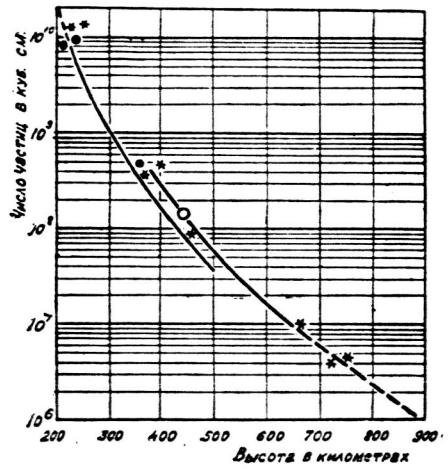


Рисунок 3.
Кривая изменения плотности нейтральных частиц с высотой, полученная различными методами.

На рисунке — ● — результаты определения плотности по изучению торможения советских спутников.

O — результат определения плотности по диффузии натриевого облака.

* — данные, приведенные в мировой литературе, по изучению торможения советских и американских спутников.

Сплошные линии — соответствуют результатам, полученным с помощью манометров, установленных на третьем советском спутнике, и по радиосигналам первого советского спутника.

Figure 3. Curve of density change of neutral particles with altitude, obtained by various methods.
The symbol ● represents the results of density determination by studying the drag of Soviet satellites.
The symbol o represents the result of density determination by the diffusion of a sodium cloud.
The symbol * represents data quoted in world literature, according to the study of drag of Soviet and American satellites.
Solid lines represent the results which were obtained with manometers on Sputnik III and by radio-signals from Sputnik I.

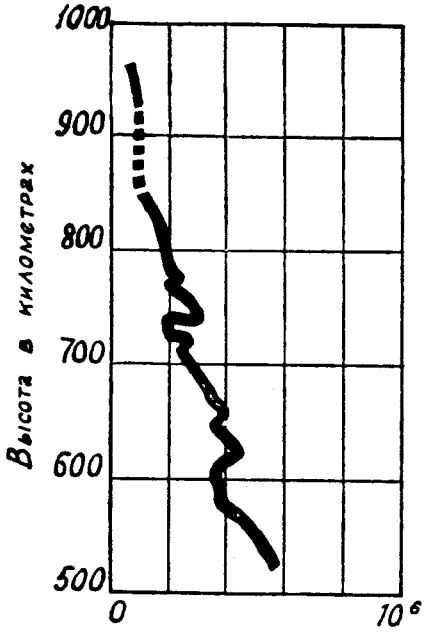


Рисунок 4.

Кривая изменения концентрации положительных ионов с высотой, полученная с помощью установленных на третьем советском спутнике ионных ловушек 19 мая 1958 г. (около 11 часов московского времени). Сплошная линия—данные измерений. Пунктир—интерполированные данные.

Figure 4. Curve of change in concentration of positive ions with altitude, obtained with the help of ion traps which were installed on Sputnik III on May 19, 1958 (about 11 p.m. Moscow time).
Solid line, data of measurements
Broken line, interpolated data.

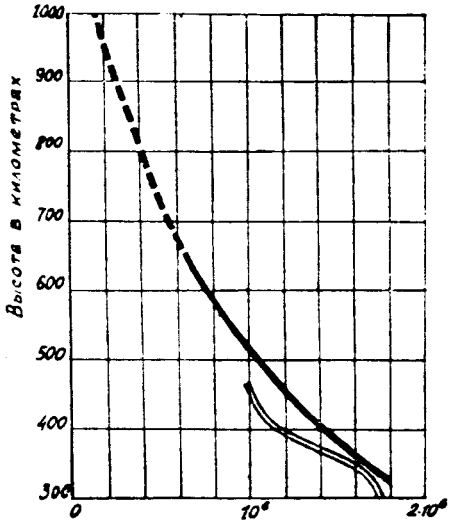


Рисунок 5.

Кривые изменения электронной концентрации с высотой, полученные в результате обработки записей радиосигналов первого советского искусственного спутника Земли 5—8 октября 1957 г. от 7 ч. 40 м. до 9 ч. 40 м. (сплошная линия) и при пуске высотной геофизической ракеты 21 февраля 1958 г. в 11 ч. 40 м. (двойная линия). Пунктиром отмечены экстраполированные данные. По горизонтали — число электронов в кубическом сантиметре.

Figure 5. Curve of change in electron concentration with altitude, obtained as a result of the processing of radio signal recordings from Sputnik I on October 5-8, 1957, from 7:40 a.m. to 9:40 a.m. (solid line) and during the launching of a high altitude geophysical rocket on February 21, 1958, 11:40 a.m. (double line). The broken line indicates extrapolated data. On the horizontal axis is shown the number of electrons per cubic centimeter; on the vertical axis, altitudes in kilometers.

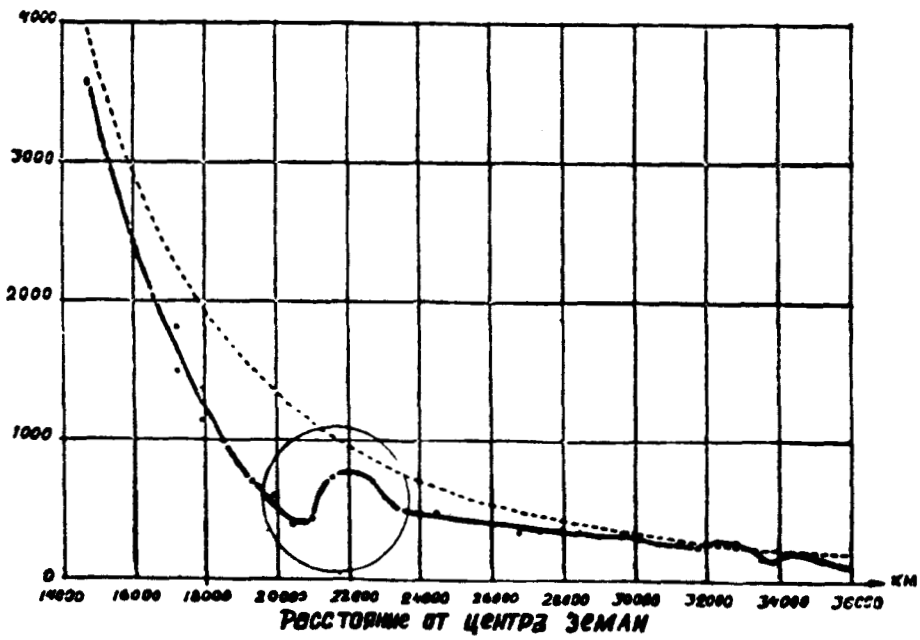


Рисунок 6.

Кривая изменения напряженности магнитного поля Земли с высотой. Кружком отмечен эффект внеионосферного токового кольца, обнаруженного при полете советской космической ракеты. По вертикали — напряженность магнитного поля Земли в гаммах. Пунктир — вычисленные значения напряженности магнитного поля Земли. Сплошная линия — данные измерений.

Figure 6. Curve of change in intensity of the earth's magnetic field. The circle indicates the effect of the current ring outside of the ionosphere, which was discovered during the flight of the Soviet cosmic rocket (Myetchta). The vertical axis indicates the intensity of the earth's magnetic field in gamma; the horizontal axis the distance from the center of the earth in kilometers. The broken line represents the calculation of the value of intensity of the earth's magnetic field. The solid line represents the measurements data.

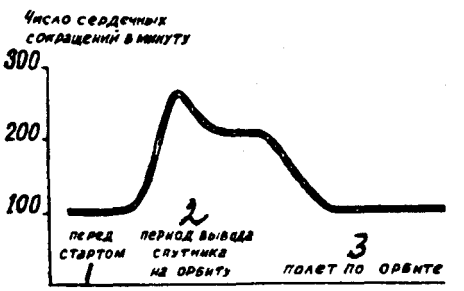


Рисунок 7.
Кривая частоты сердечных сокращений собаки «Лайка» в различные моменты полета.

Figure 7. Curve of frequency of heart systoles of the dog Laika at various moments of flight.
On the vertical axis, the number of heart systoles per minute;
1, before start;
2, period of entering orbit;
3, flight in orbit.

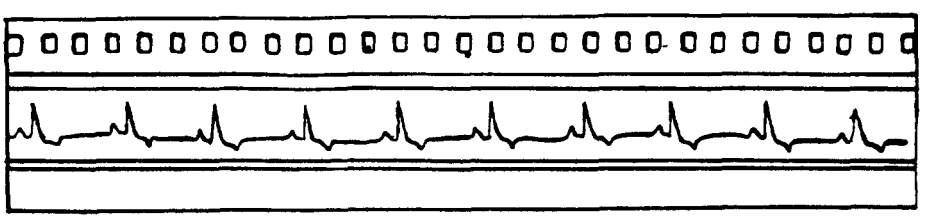


Рисунок 8.
Запись электрокардиограммы собаки «Лайка» в состоянии невесомости, полученная на втором советском искусственном спутнике Земли.

Figure 8. Recording of electrocardiograph of Laika during a state of weightlessness, obtained from Sputnik II.